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COMPUTER AIDED PARAMETRIC SONAR DESIGN UPDATE.(U)

OCT 73 E C GANNON, R P PINGREE

UNCLASSIFIED NUSC-TM-TD1X-59-73 NL

1 OF 1

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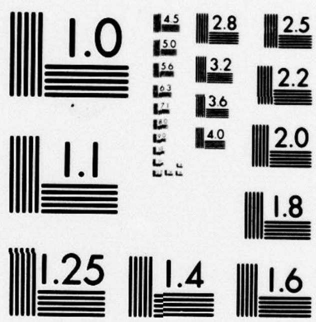

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2 LEVEL II

NUSC ~~TM No.~~ TD1X-59-73

NAVAL UNDERWATER SYSTEMS CENTER
Newport, Rhode Island 02840

Technical ~~Memorandum~~

COMPUTER AIDED PARAMETRIC SONAR DESIGN UPDATE.

30 October 1973

37

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E. C. Gannon
~~Parametric~~ Sonar Group

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Digital Computing Division

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TM No.
TD1X-59-73

ABSTRACT

A computer program was written that simplifies the design of parametric sonars. This program has since been modified to update the calculation for secondary directivity index and to include calculations for secondary beamwidth and primary beamwidth. The tolerance on the determination of secondary source level has been reduced from ±1.0 dB to ±0.5 dB with a consequent tightening of tolerances on all other related calculated quantities. Finally, a new plotting method has been introduced to give plots in the form of families of curves for ease of design analysis.

ADMINISTRATIVE INFORMATION

This work was prepared under Project No. A-614-19, Principal Investigator, Dr. A. J. Van Woerkum, Code TC.

The authors of this memorandum are located at the New London Laboratory, Naval Underwater Systems Center, New London, Connecticut.

The authors wish to acknowledge Dr. M. B. Moffett for his help.

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INTRODUCTION

A computer program aimed at automating the design process for parametric sonars was written.[1] The program allows the designer to work from a known secondary source level (LSS) and a known secondary frequency (F) for a range of values of projector area (A), primary source level per tone (LSP) and a given stepdown ratio (FO/F). The program will build a matrix of possible designs that can be compared to other factors to achieve a workable and realistic design. This computer program is based on the Mellen and Moffett theory.[2]

Some new information in the area of directivity index, a tightening of the tolerances on the computed data, and an alternate routine for plotting data have been incorporated into the original program. Since the computer program and its use has been discussed in detail in the earlier memorandum,[1] only the changes and their effects will be taken up in this memorandum.

CHANGES

The program remains basically the same as that discussed in the earlier memorandum.[1] The changes are a result of new information about the directivity, a desire to tighten the tolerances on the computed information, and a need for a plot that arranges the data in the form of a family of curves for ease of analysis.

Directivity Index and 3 dB bandwidth

Investigation has revealed that the original expression for directivity index by Mellen and Moffett[2] does not always predict the secondary frequency directivity index (NDIS) accurately. A new expression was developed by Moffett[3] which was deemed more accurate over the region of concern. This expression is

$$\text{NDIS} = \text{NDIP} - 10\ \text{LOG}\ (\text{Ye}^{-0.65\text{Y}(\text{F/FO})^2} + 1/2) \qquad (1)$$

where $$\text{Y} = \pi\chi\text{F}/[5(\text{GL})(\text{FO})] + 0.685\ (\text{AL})(\text{RO})(\text{FO})/\text{F} \qquad (2)$$

F = Secondary Frequency in kHz[1]

FO = Primary Frequency in kHz[1]

NDIP = Primary directivity index in dB[1]

GL = Parametric gain in linear units

χ = Primary saturation number.[2] In this program a table of these numbers is created for use.[1]

AL = Absorption loss in nepers/meter[1]

A related term that is now calculable is the secondary frequency 3 dB beamwidth (BWS). This is expressed as

$$BWS = BWP \sqrt{Ye^{-0.65Y(FO/F)^2} + 1/2} \quad \text{deg.} \qquad (3)$$

As can be seen from the expression, BWS depends on the primary frequency 3 dB beamwidth (BWP). In this program, BWP is selected as being for a circular piston and this is expressed as

$$BWP = (3.24)\ (5.73) \sqrt{4\pi A(FO)^2 (10^3)^2 / C^2} \quad \text{deg.} \qquad (4)$$

where C = Sound velocity in meters/second.

The expressions for NDIS and BWS contain an aperture correction originally derived from circular piston theory. However, the expressions are also applicable to square piston projectors. Thus all of the computed information relating to beamwidths and NDIS applies to circular and square piston projectors.

A complete computer printout of a sample example is shown in Appendix A. The sample example is the same one used in reference 1 so that the difference between the new and old programs can be compared. The NDIS column in the output tables now reflects the new theory. Also, two new columns appear, one for BWS and the other for BWP.

Tolerance

In order to solve a given problem, the computer program must compare each calculated value of LSS for each data point against a nominal secondary frequency source level (LSSI) value that is put into the computer in the input data. The tolerance on this comparison was ±1.0 dB in the old form of the program.[1] The new tolerance is ±0.5 dB. Thus, the tolerance on all other computed values that depend on LSS is proportionately tighter than under previous conditions. These quantities and their new tolerances are:

G = Parametric Gain ±0.5 dB,

LSP = Primary Frequency Source Level per tone ±0.5 dB,

PADB = Acoustic power per primary frequency ±0.5 dB.

The PA which is the acoustic power per primary frequency in watts is also proportionately more accurate, as the $\pm$0.5 dB tolerance for PADB implies. The new formula for NDIS as well as the formulas for BWS and BWP depend on GL and χ where

$$GL = \text{antilog } (G/20)$$

and χ is selected from a table of χ values formed by the program according to an equation. Because GL and χ always appear as the ratio $\chi/(GL)$, the tolerances on NDIS, BWS and BWP will never exceed $\pm$1.0 dB. The tolerances on NDIS, BWS and BWP will vary and depend on the operating point on the Mellen and Moffett[2] curves.

An equation for determing a table of χ values has been mentioned. This equation determines the increment of χ in a table formed by the program and stored in the computer for use in determining the values of LSS through the use of a numerical integration algorithm by Goldstein.[4] The table is formed such that each next increasing value of χ is a fixed percentage of the previous value. In order to reduce the tolerance on LSS it was necessary to reduce the fixed percentage increase on successive values of χ. The required new formula for χ is

$$\chi_{(I+1)} = 1.04881\ \chi_I$$

for 172 values starting from $\chi_0 = 0.00953462$.

New Plots

When it comes to analyzing the results for a given set of design parameters, the single on-line plots of LSS vs FO/F and NDIS vs FO/F for each different combination of secondary frequency (F), area (A) and nominal source level (LSSI) are cumbersome. What has been devised to overcome this shortcoming is plots of LSS vs FO/F and NDIS vs FO/F for a given family of LSS values for each combination of F and A. Figures 1 through 6 show the results of this new plotting method for the sample example of Appendix A. The plots were made on an off-line plotter (Calcomp) that is used with the Univac 1108 computer.

These plots can save many man hours of hand plotting to achieve a similar matrix. Also, the family of curves approach places all of the data for a given F and A on one piece of paper and allows the designer to conveniently view all the available trade-offs. How the new plotting method fits into the computer program flow is shown in Figure 7.

CONCLUSION

A computer program to aid in the design of parametric sonars has been upgraded. The latest information has been incorporated in calculating the secondary frequency directivity index (NDIS). Also two new quantities have been introduced. They are the secondary frequency 3 dB beamwidth (BWS) and the primary frequency 3 dB beamwidth (BWP). These three quantities are valid for a circular and square piston projector.

The tolerances on the calculated information have been tightened. Thus, for example, the secondary source level (LSS) can now be computed to ± 0.5 dB.

A new plotting method using the family of curves approach is now used. Plots of acoustic power per tone vs downshift ratio (PADB vs FO/F) and secondary directivity index vs downshift ratio (NDIS vs FO/F) can now be made for a family of LSS values for a fixed secondary frequency (F) and a projector area (A). This new type of plot enables the designer to more readily observe trends and to make tradeoffs.

REFERENCES

1. Gannon, E. C. and R. P. Pingree, "Computer Aided Parametric Sonar Design," NUSC Technical Memorandum No. TD1X-33-72, 23 May 1973 (Unclassified).

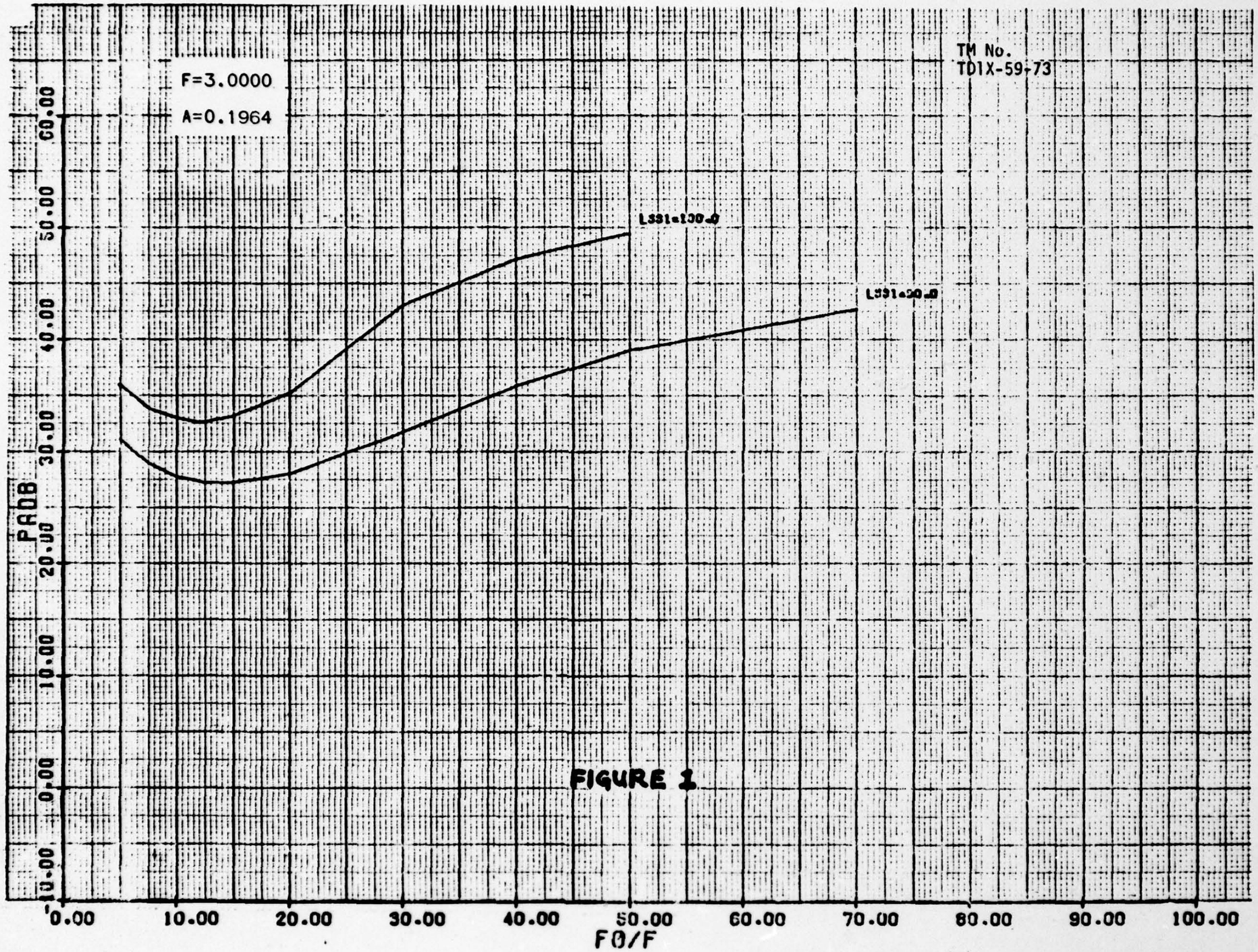
2. Mellen, R. H. and M. B. Moffett, "A Model for Parametric Radiator Design," USN Journal of Underwater Acoustics, Vol. 22, No. 2, April 1972 (Unclassified).

3. Moffett, M. B. "personal communication and papers" Aug 1973 (Unclassified).

4. Goldstein, M., "On a Numerical Integration in Parametric Sonar Research," NUSC Technical Memorandum No. PA4-268-71, 21 Oct 1971, (Unclassified).

FIGURES 1 THROUGH 3

DESIGN CURVES (PADB VS FO/F)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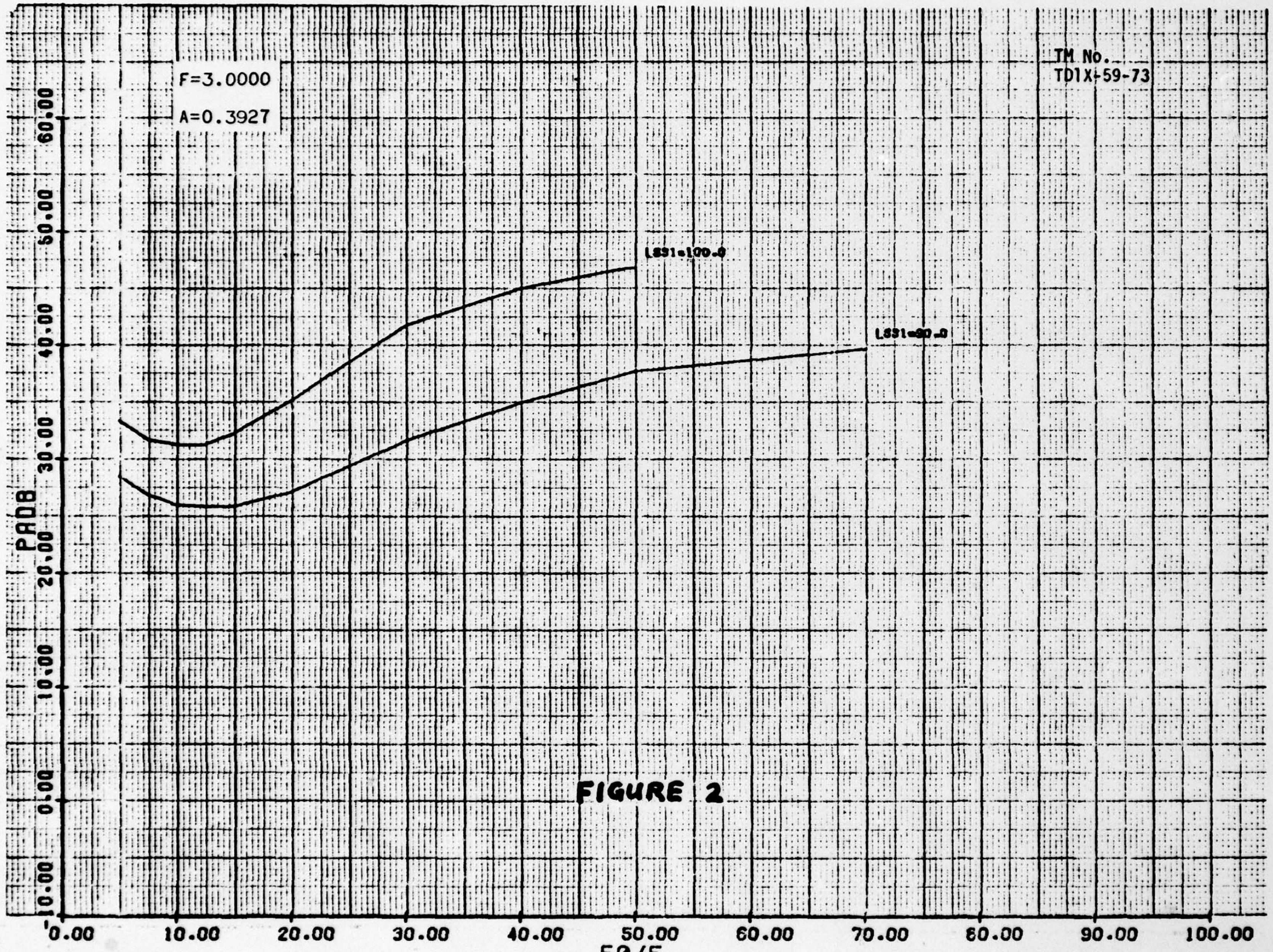
40.00
50.00
60.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
F0/F

FIGURE 1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0.00
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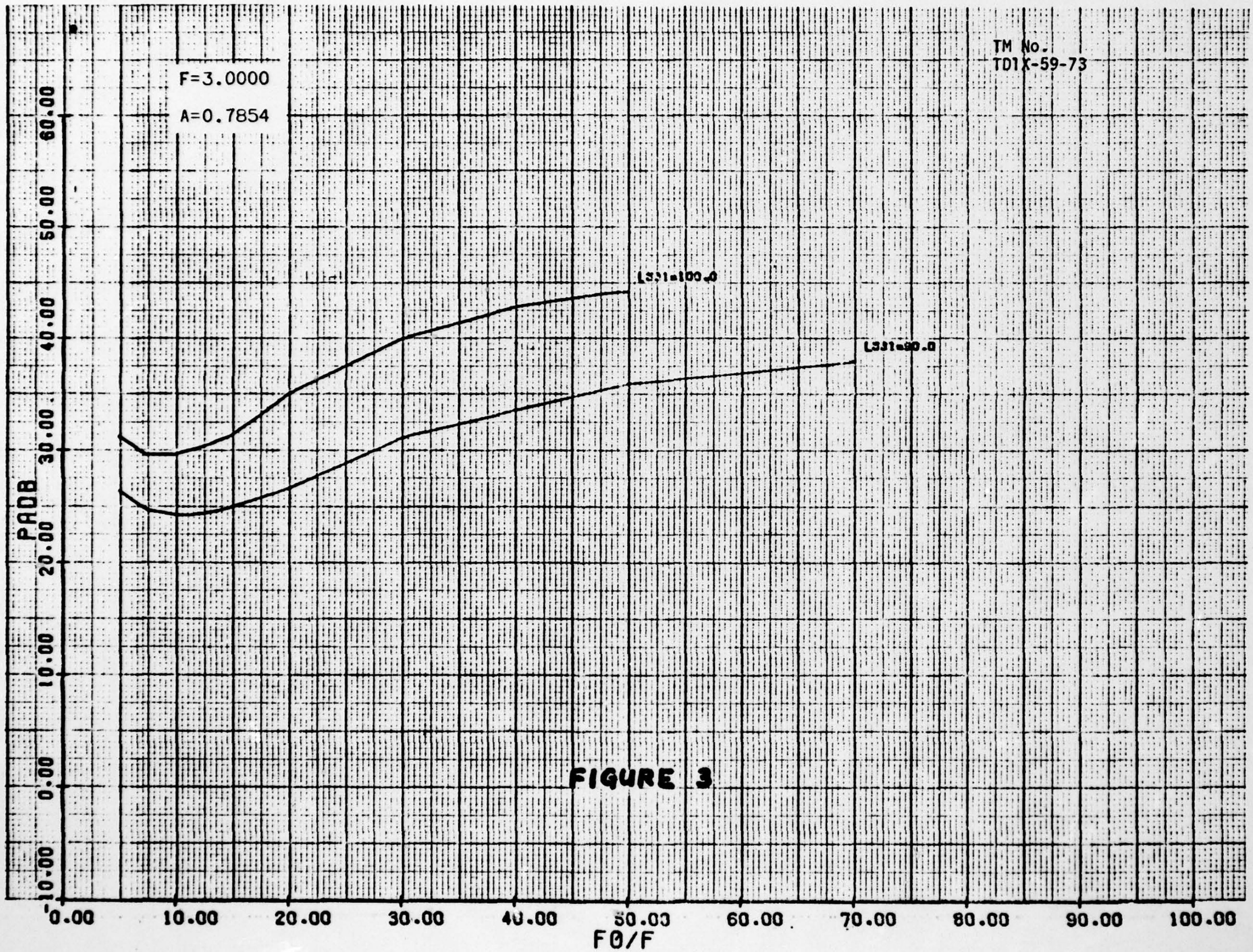
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
F0/F

FIGURE 2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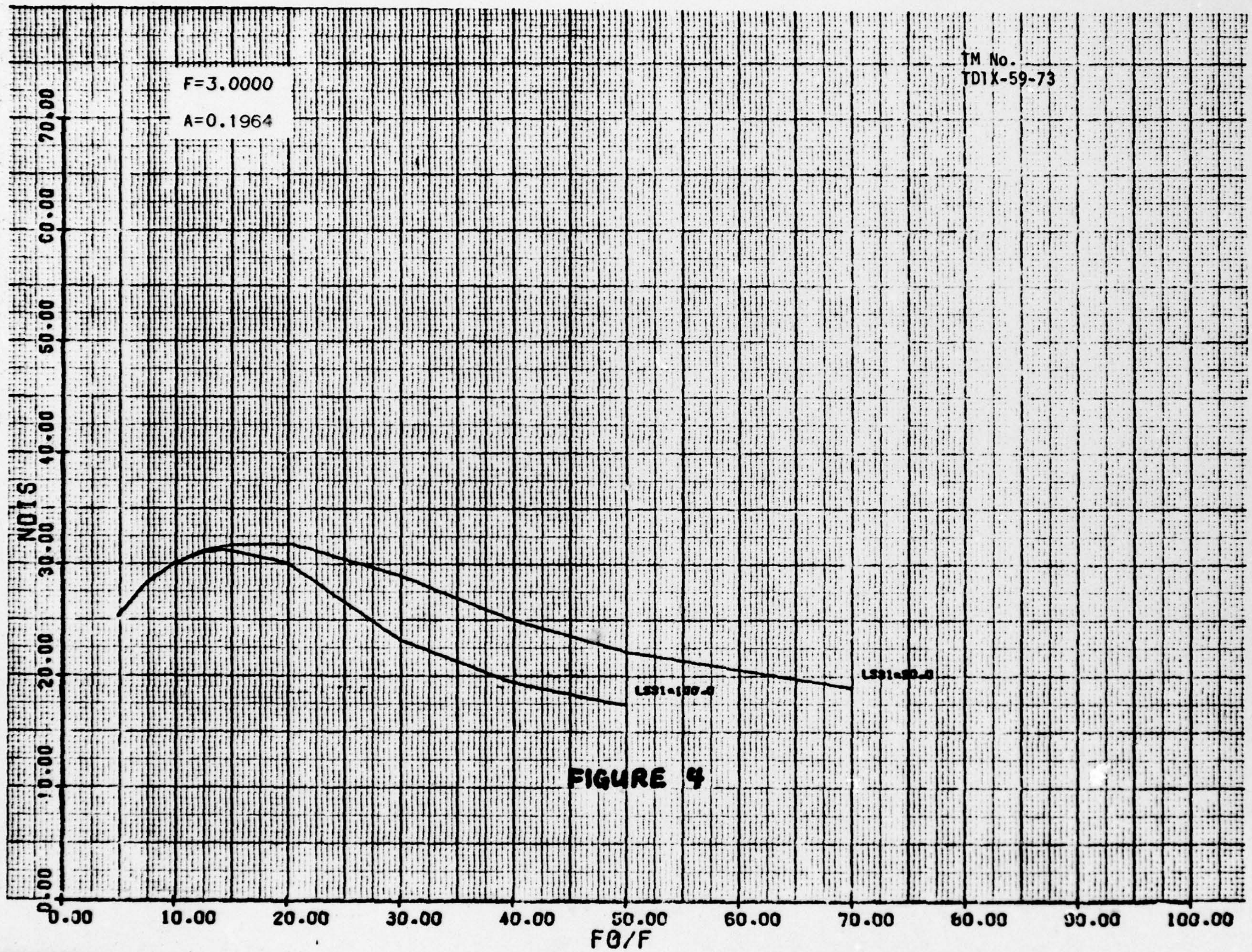
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
F0/F

FIGURE 3

FIGURES 4 THROUGH 6

DESIGN CURVES (NDIS VS FO/F)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NDIS
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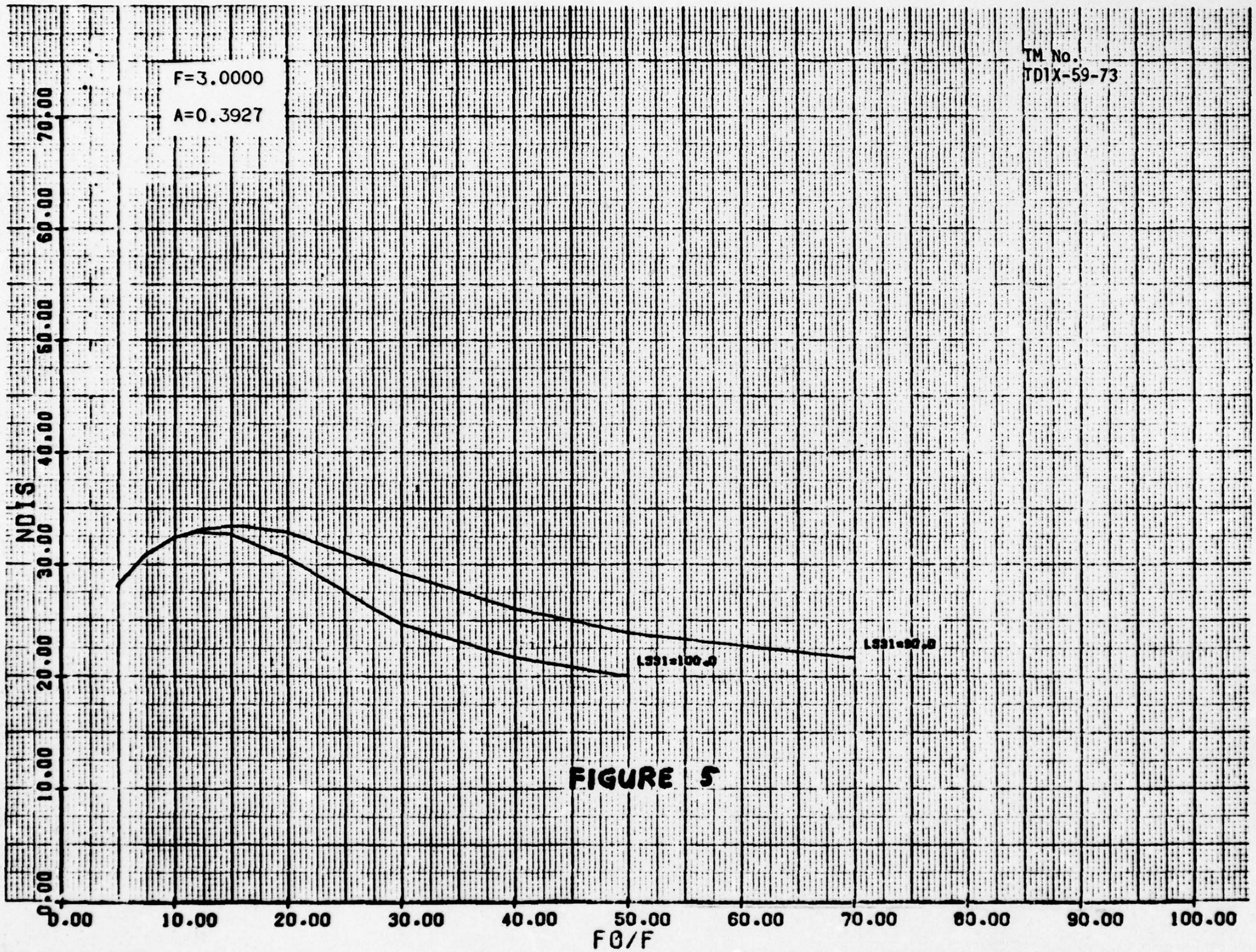
100.00
F0/F

FIGURE 4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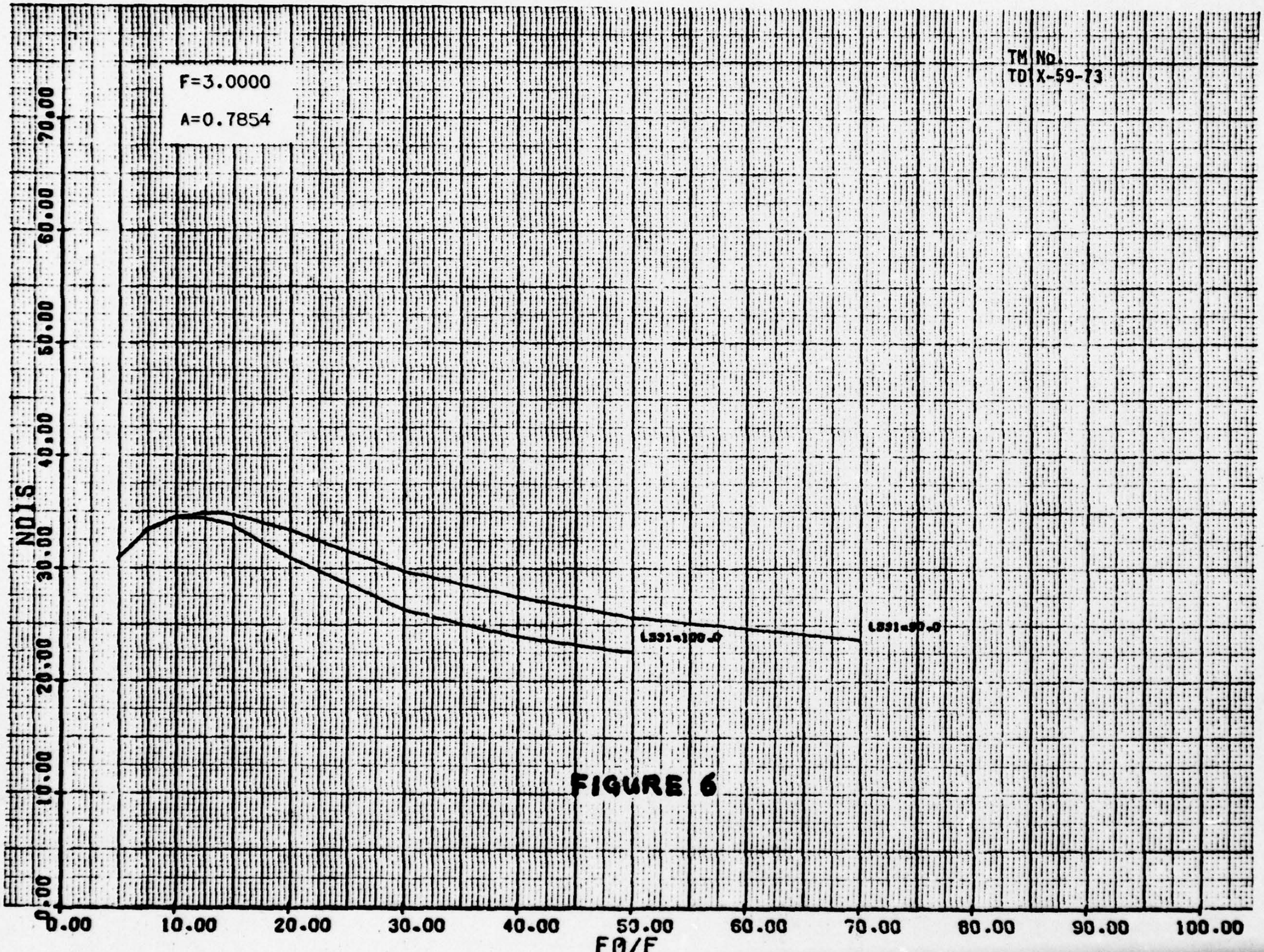
100.00
F0/F
LS31=100.0

FIGURE 5



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A=0.7854
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TD X-59-73
NDIS
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100.00
F0/F

FIGURE 6

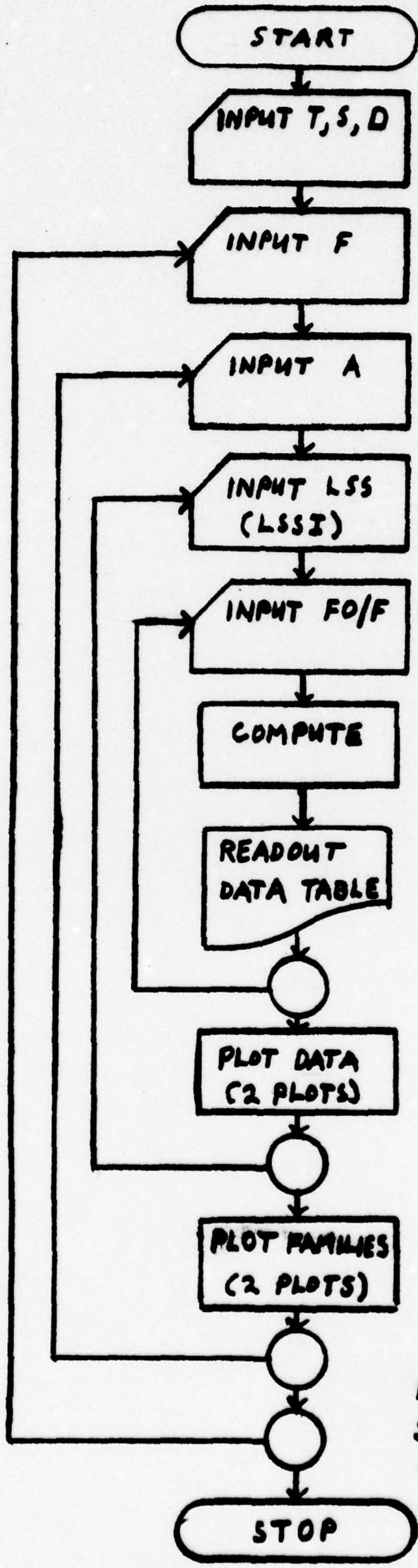

FIGURE 7

PARAMETRIC SONAR DESIGN, SIMPLIFIED FLOW CHART, UPDATED

APPENDIX A

This appendix shows a sample example and the form the tables and on-line plots take as they come out of the computer. The off-line plots were shown in Figures 1 through 6 in the main text.

```
PARAMETRIC SONAR DESIGN-LSS AND NDIS-CIRCULAR PISTON
 T= WATER TEMPERATURE (DEGREES C)
 D= PROJECTOR DEPTH (METERS)
 S= SALINITY (PPT)
 F= SECONDARY FREQUENCY (KHZ)
 A= PROJECTOR AREA (SQ. METERS)
 FO/F= DOWNSHIFT RATIO
 FO= PRIMARY FREQUENCY (KHZ)
 AL= ABSORPTION CONSTANT (NEPERS/METER)
 1/2AL= REACTION LIMIT (METERS)
 RO= RAYLIEGH DISTANCE (METERS)
 NDIP= DIRECTIVITY INDEX-PRIMARY (DB)
 LSS= SECONDARY SOURCE LEVEL (DB//MICROBAR-METER)
 LSP= PRIMARY SOURCE LEVEL (DB//MICROBAR-METER)
 L*= SCALED SOURCE LEVEL (DB//MICROBAR-METER-KHZ)
 G= PARAMETRIC GAIN (DB)
 PA= ACOUSTIC POWER PER TONE (WATTS)
 ΔNDI= DIRECTIVITY GAIN (DB)
 NDIS= SECONDARY DIRECTIVITY INDEX (DB)
 PADB=ACOUSTIC POWER(DB//WATT) PER EACH PRIMARY TONE
 BWP=PRIMARY 3 DB. BEAMWIDTH DEGREES
 BWS=SECONDARY 3 DB. BEAMWIDTH DEGREES
```

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T= 7.

D= .0

S= 35.

C= 1479.

A= .1964

F= 3.000

BWP	BWS	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NDIS	ΔNDI
11.7	10.0	31.2	5.00	15.000	.000241	2079.	2.	1043.5	24.0	90.2	126.0	149.5	-35.8	1303.8	25.4	1.4
7.8	7.1	29.1	7.50	22.500	.000506	988.	3.	330.5	27.6	90.2	127.4	154.5	-37.3	808.3	28.4	.8
5.8	5.7	27.8	10.00	30.000	.000846	591.	4.	148.3	30.1	89.8	128.7	158.2	-38.9	603.1	30.2	.1
4.7	5.0	27.2	12.50	37.500	.001237	404.	5.	81.1	32.0	89.7	130.0	161.5	-40.3	529.5	31.3	-.7
3.9	4.7	27.4	15.00	45.000	.001657	302.	6.	50.5	33.6	90.2	131.8	164.8	-41.5	547.4	31.9	-1.7
2.9	4.7	28.2	20.00	60.000	.002510	199.	8.	25.0	36.1	90.5	135.1	170.6	-44.6	657.7	32.0	-4.1
1.9	6.6	31.9	30.00	90.000	.004021	124.	12.	10.4	39.6	90.1	142.3	181.4	-52.3	1548.5	29.0	-10.6
1.5	10.4	36.0	40.00	120.000	.005186	96.	16.	6.1	42.1	89.5	148.9	190.5	-59.4	3988.6	25.1	-17.0
1.2	14.4	39.2	50.00	150.000	.006109	82.	20.	4.1	44.0	89.8	154.0	197.5	-64.2	8257.9	22.2	-21.8
.8	20.8	42.8	70.00	210.000	.007653	65.	28.	2.3	47.0	90.2	160.6	207.1	-70.4	19249.1	19.0	-28.0
.0	.0	.0	100.00	300.000	.009969	50.	40.	1.3	50.1	83.4	.0	210.4	-76.9	L*>210.		

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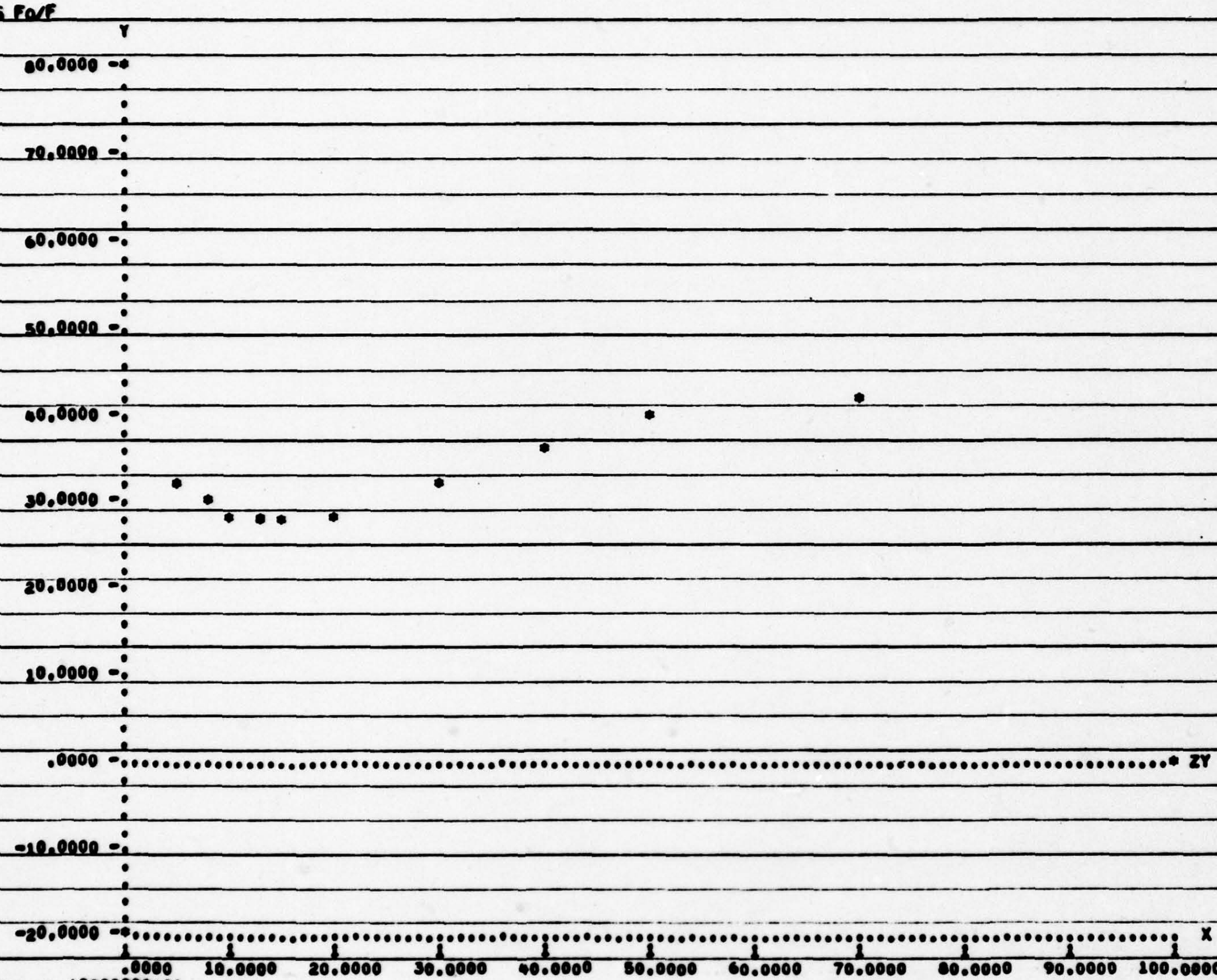
PADB VS Fo/F



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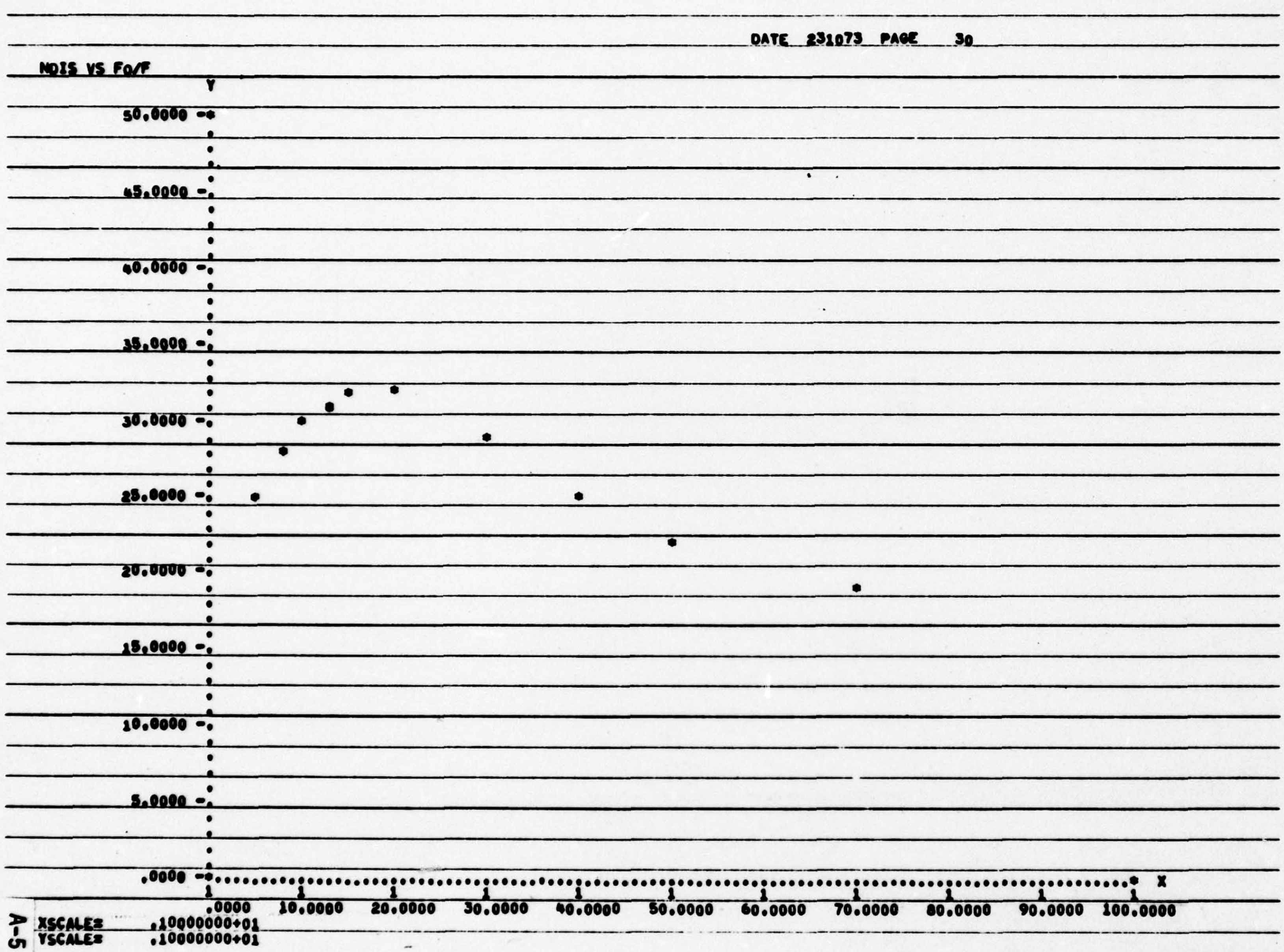
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NDIS VS Fo/F
Y
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45.0000
40.0000
35.0000
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25.0000
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15.0000
10.0000
5.0000
.0000
X
.0000
10.0000
20.0000
30.0000
40.0000
50.0000
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80.0000
90.0000
100.0000
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YSCALE= .10000000+01

DATE 231073 PAGE 32

T= 7.

D= .0

S= 35.

C= 1479.

A= .1964

F= 3.000

BWP	B=S	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NDIS	ΔNDI
11.7	10.0	36.1	5.00	15.000	.000241	2079.	2.	1043.5	24.0	100.1	131.0	154.5	-30.9	4092.0	25.4	1.3
7.8	7.1	34.0	7.50	22.500	.000506	988.	3.	330.5	27.6	99.9	132.4	159.5	-32.5	2536.8	28.3	.8
5.8	5.8	33.2	10.00	30.000	.000846	591.	4.	148.3	30.1	100.1	134.1	163.6	-34.0	2082.0	30.1	.0
4.7	5.2	32.6	12.50	37.500	.001237	404.	5.	81.1	32.0	99.6	135.4	166.9	-35.8	1828.0	31.1	-.9
3.9	5.0	33.2	15.00	45.000	.001657	302.	6.	50.5	33.6	100.1	137.6	170.6	-37.4	2078.7	31.4	-2.2
2.9	5.7	35.2	20.00	60.000	.002510	199.	8.	25.0	36.1	100.0	142.1	177.7	-42.1	3324.6	30.3	-5.8
1.9	12.5	43.1	30.00	90.000	.004021	124.	12.	10.4	39.6	100.2	153.5	192.6	-53.3	20302.1	23.4	-16.2
1.5	19.4	47.2	40.00	120.000	.005186	96.	16.	6.1	42.1	100.2	160.1	201.7	-59.9	52293.3	19.6	-22.5
1.2	24.6	49.5	50.00	150.000	.006109	82.	20.	4.1	44.0	100.2	164.4	207.9	-64.2	89476.7	17.6	-26.5
.0	.0	.0	70.00	210.000	.007653	65.	28.	2.3	47.0	93.2	.0	210.4	-70.3		L*>210.	
.0	.0	.0	100.00	300.000	.009469	50.	40.	1.3	50.1	83.4	.0	210.4	-76.9		L*>210.	

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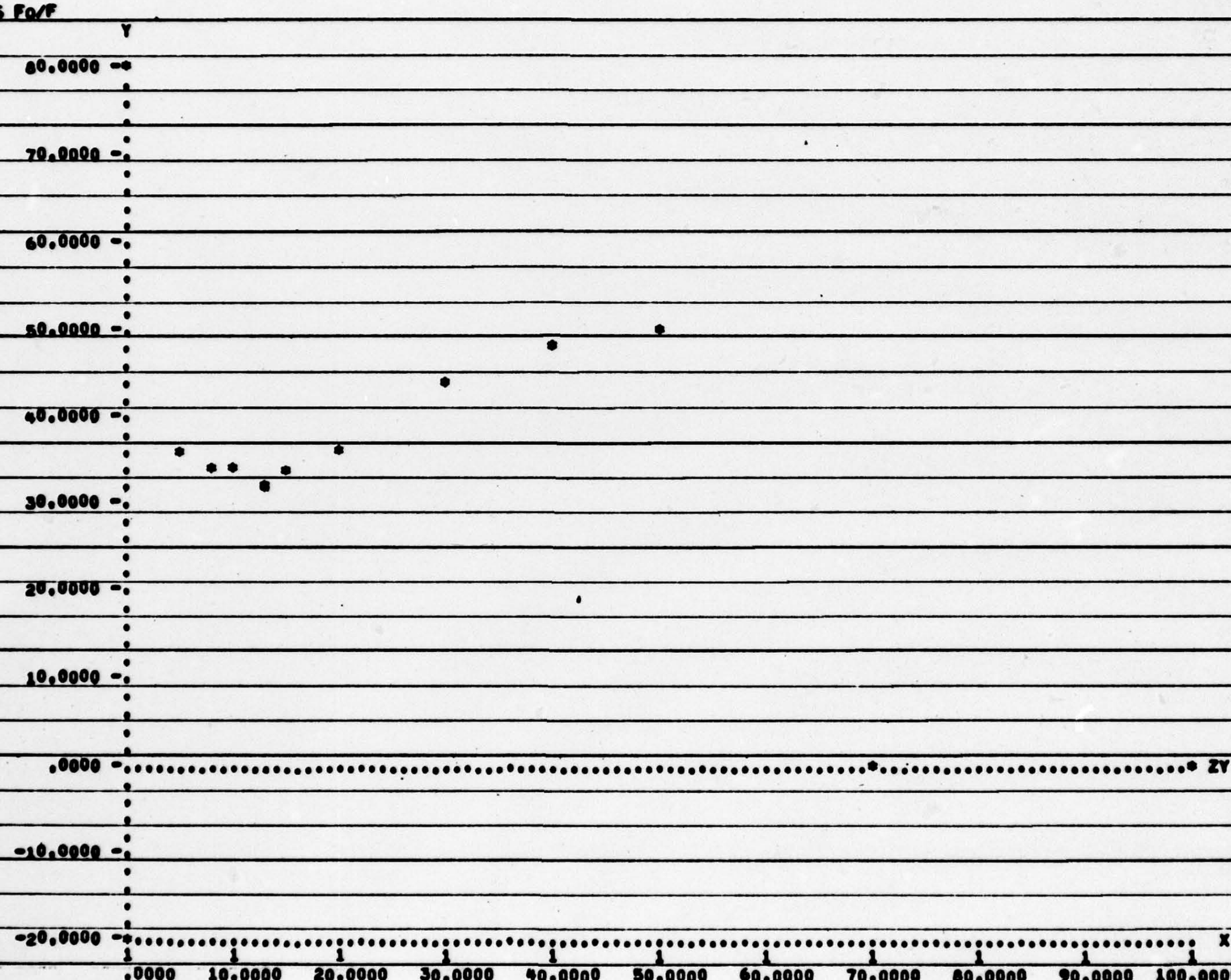
PADB VS Fo/F



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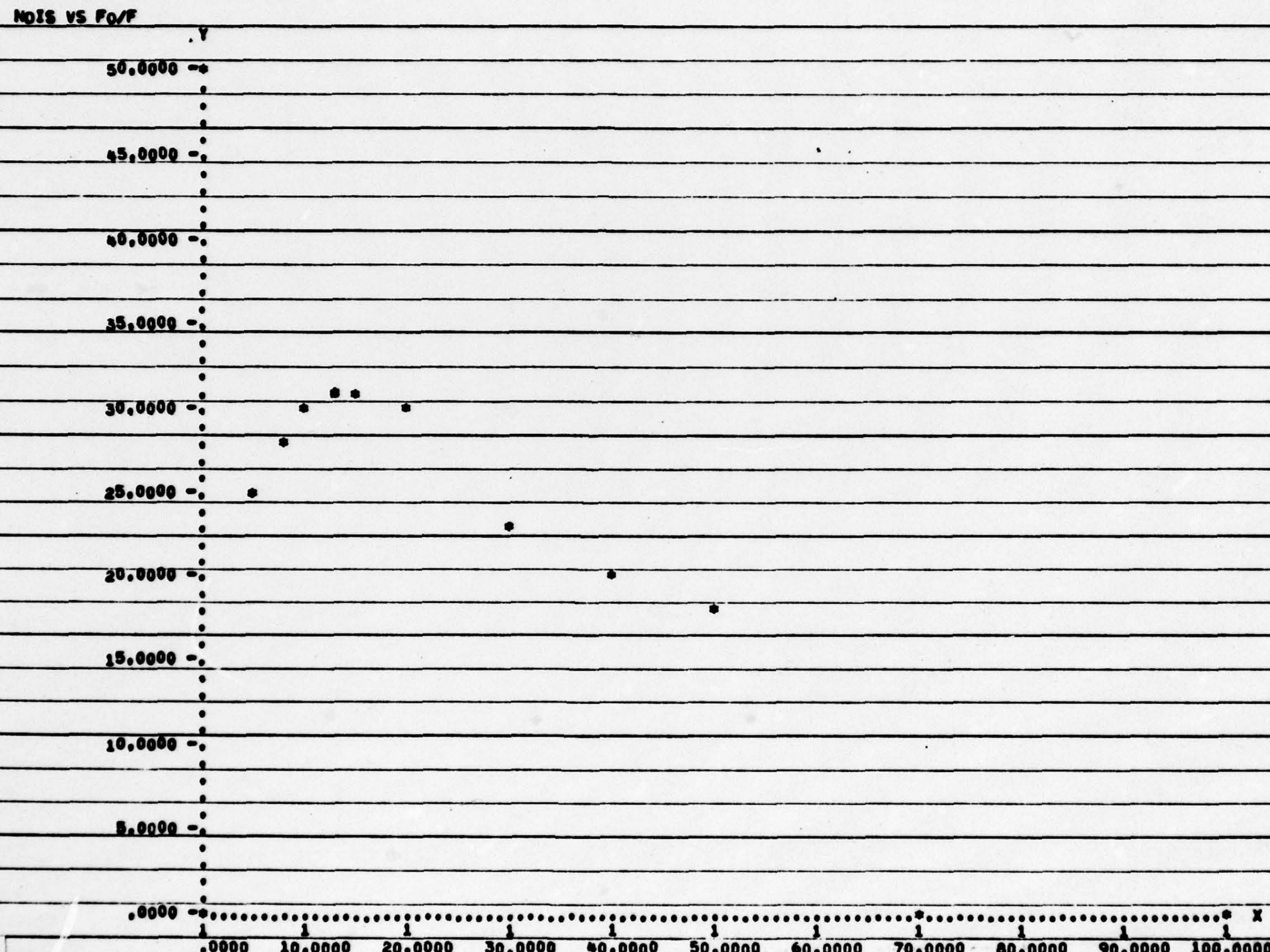

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D= .0

S= 35.

C= 1479.

A= .3927

F= 3.000

BWP	BWS	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NDIS	ΔNDI
8.2	7.2	28.6	5.00	15.000	.000241	2079.	4.	521.9	27.1	89.9	126.4	149.9	-36.5	717.3	28.2	1.2
5.5	5.2	26.9	7.50	22.500	.000506	988.	6.	165.3	30.6	90.2	128.3	155.3	-38.1	489.1	31.0	.4
4.1	4.4	26.0	10.00	30.000	.000846	591.	8.	74.1	33.1	90.1	129.9	159.5	-39.8	401.4	32.6	-.5
3.3	4.0	25.9	12.50	37.500	.001237	404.	10.	40.6	35.0	90.2	131.7	163.2	-41.5	387.7	33.4	-1.6
2.7	3.9	26.0	15.00	45.000	.001657	302.	12.	25.3	36.6	90.1	133.4	166.5	-43.3	400.8	33.6	-3.0
2.1	4.2	27.2	20.00	60.000	.002510	199.	16.	12.5	39.1	89.9	137.1	172.7	-47.2	529.8	32.9	-6.2
1.4	6.4	31.8	30.00	90.000	.004021	124.	24.	5.2	42.6	90.1	145.2	184.3	-55.1	1509.2	29.3	-13.4
1.0	9.1	35.1	40.00	120.000	.005186	96.	32.	3.0	45.1	89.8	151.0	192.6	-61.2	3212.7	26.1	-19.0
.8	11.9	37.8	50.00	150.000	.006109	82.	40.	2.1	47.1	90.4	155.7	199.2	-65.3	6046.8	23.9	-23.2
.6	15.3	39.8	70.00	210.000	.007653	65.	56.	1.2	50.0	89.5	160.6	207.1	-71.1	9627.0	21.7	-28.3
.0	.0	.0	100.00	300.000	.009969	50.	80.	.6	53.1	82.7	.0	210.4	-77.7	L*>210.		

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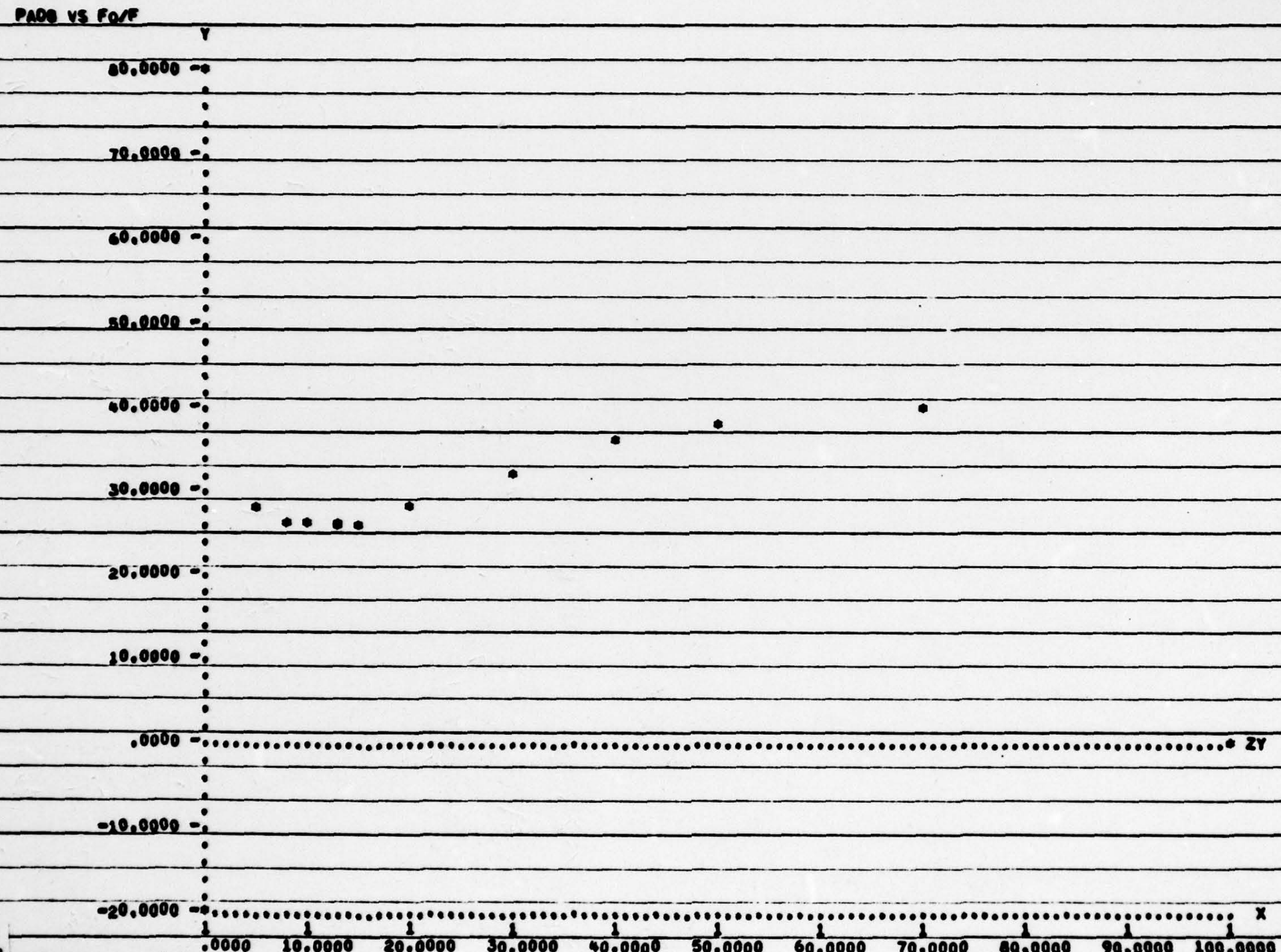

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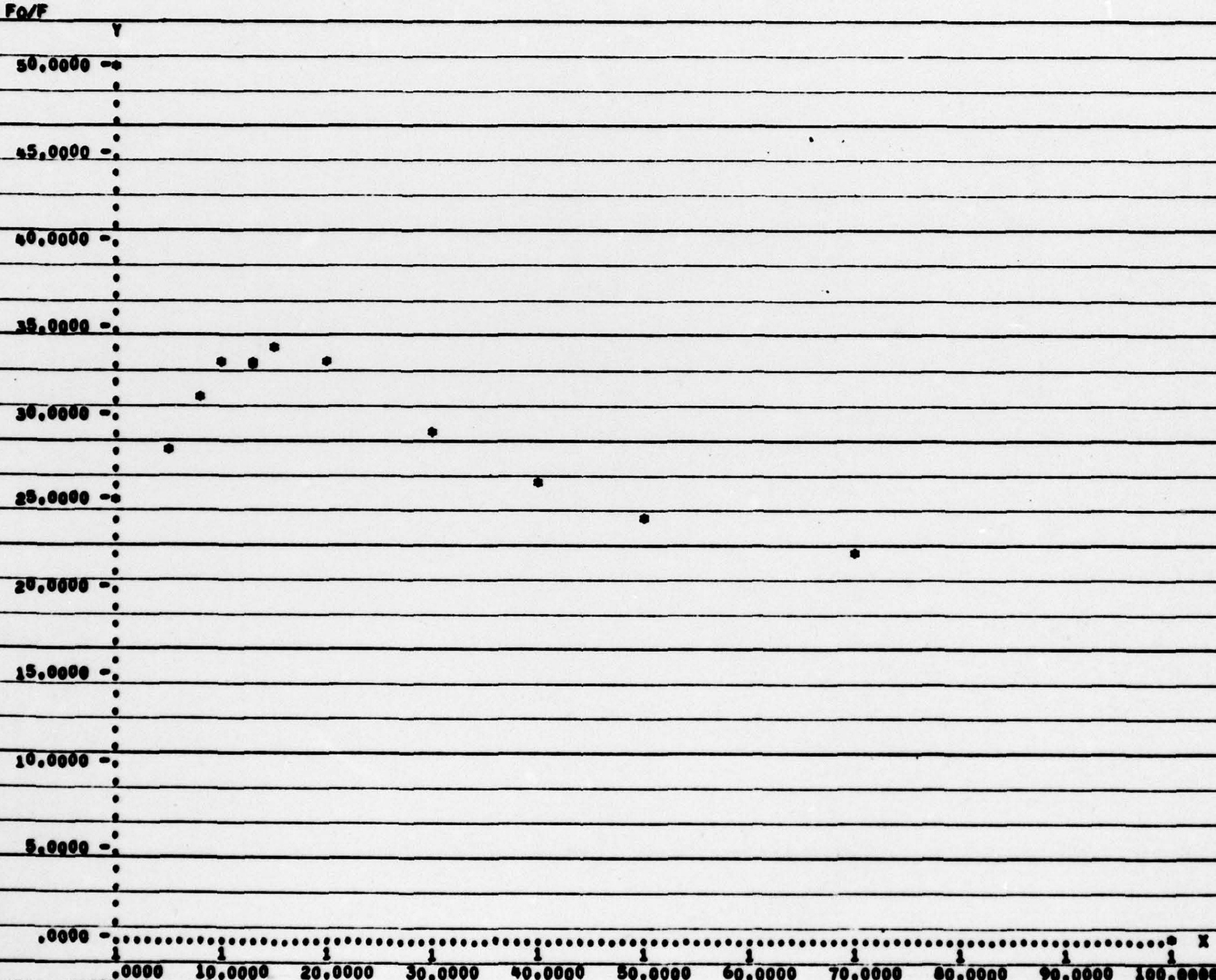

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D= .0

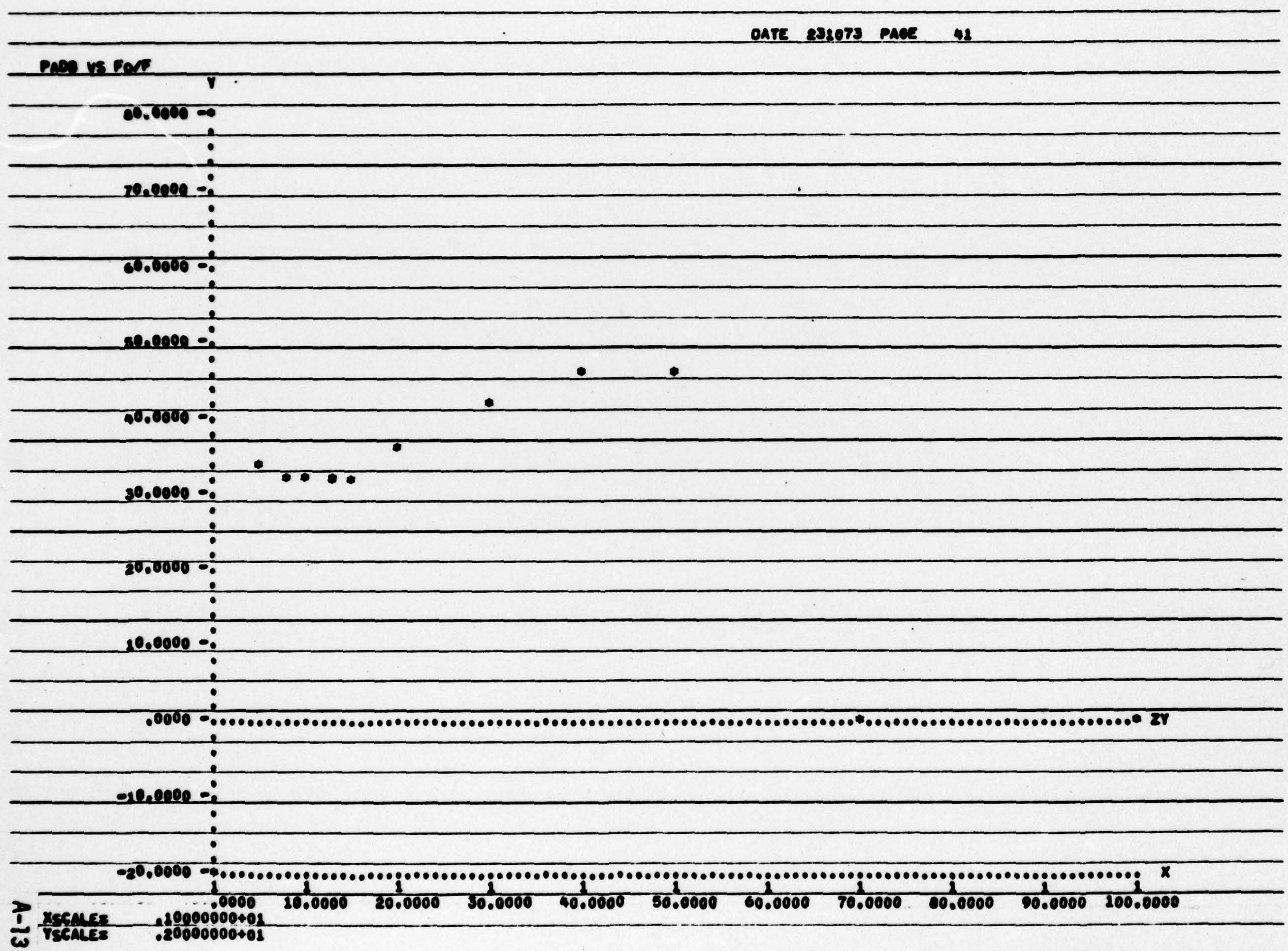
S= 35.

C= 1479.

A= .3927

F= 3.000

BWP	BWS	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NDIS	ΔNDI
8.2	7.2	33.5	5.00	15.000	.000241	2079.	4.	521.9	27.1	99.7	131.4	154.9	-31.6	2251.2	28.2	1.1
5.5	5.3	31.9	7.50	22.500	.000506	968.	6.	165.3	30.6	99.9	133.2	160.3	-33.3	1535.2	31.0	.4
4.1	4.4	31.4	10.00	30.000	.000846	591.	8.	74.1	33.1	100.3	135.3	164.8	-35.0	1385.9	32.4	-.6
3.3	4.1	31.3	12.50	37.500	.001237	404.	10.	40.6	35.0	100.0	137.1	168.6	-37.1	1338.6	33.1	-2.0
2.7	4.2	32.2	15.00	45.000	.001657	302.	12.	25.3	36.6	100.5	139.6	172.7	-39.2	1674.3	32.9	-3.7
2.1	5.4	35.1	20.00	60.000	.002510	199.	16.	12.5	39.1	100.3	145.0	180.6	-44.7	3240.2	30.8	-8.3
1.4	10.6	41.7	30.00	90.000	.004021	124.	24.	5.2	42.6	100.3	155.1	194.2	-54.9	14866.0	24.9	-17.7
1.0	14.9	45.0	40.00	120.000	.005186	96.	32.	3.0	45.1	100.3	160.9	202.5	-60.6	31645.6	21.9	-23.2
.8	18.2	46.9	50.00	150.000	.006109	82.	40.	2.1	47.1	100.1	164.8	208.3	-64.6	49224.9	20.2	-26.9
.0	.0	.0	70.00	210.000	.007653	65.	56.	1.2	50.0	92.7	.0	210.4	-70.8		L*>210.	
.0	.0	.0	100.00	300.000	.009969	50.	80.	.6	53.1	82.7	.0	210.4	-77.7		L*>210.	


DATE 231073 PAGE 41
PADB VS Fo/F
Y
80.0000
70.0000
60.0000
50.0000
40.0000
30.0000
20.0000
10.0000
.0000
-10.0000
-20.0000
ZY
X
.0000
10.0000
20.0000
30.0000
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80.0000
90.0000
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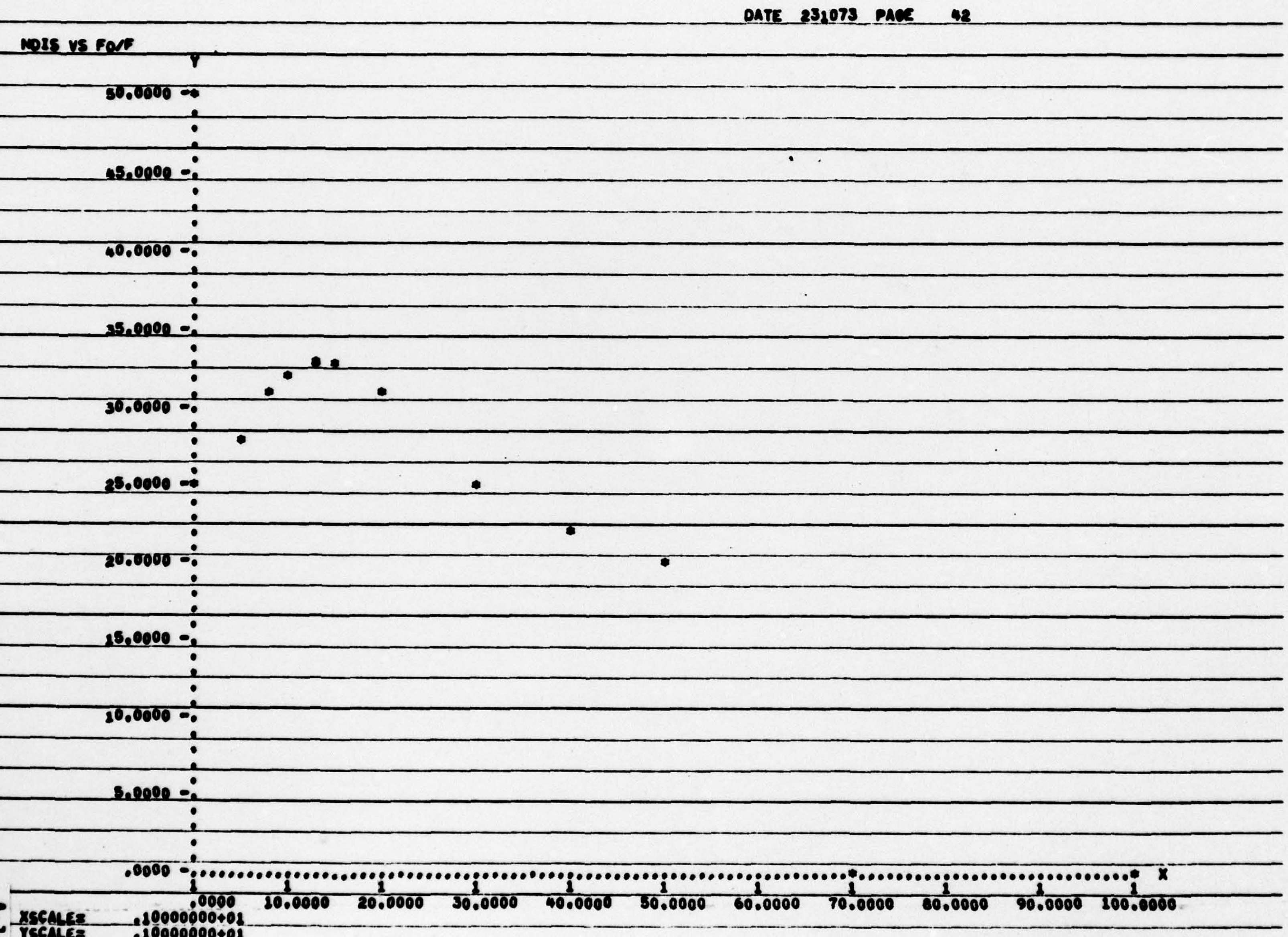
YSCALE= .20000000+01


DATE 231073 PAGE 42
NDIS VS FO/F
Y
50.0000
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35.0000
30.0000
25.0000
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15.0000
10.0000
5.0000
.0000
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.0000
10.0000
20.0000
30.0000
40.0000
50.0000
60.0000
70.0000
80.0000
90.0000
100.0000
XSCALE= .10000000+01
YSCALE= .10000000+01

DATE 231073 PAGE 44

T= 7.

D= .0

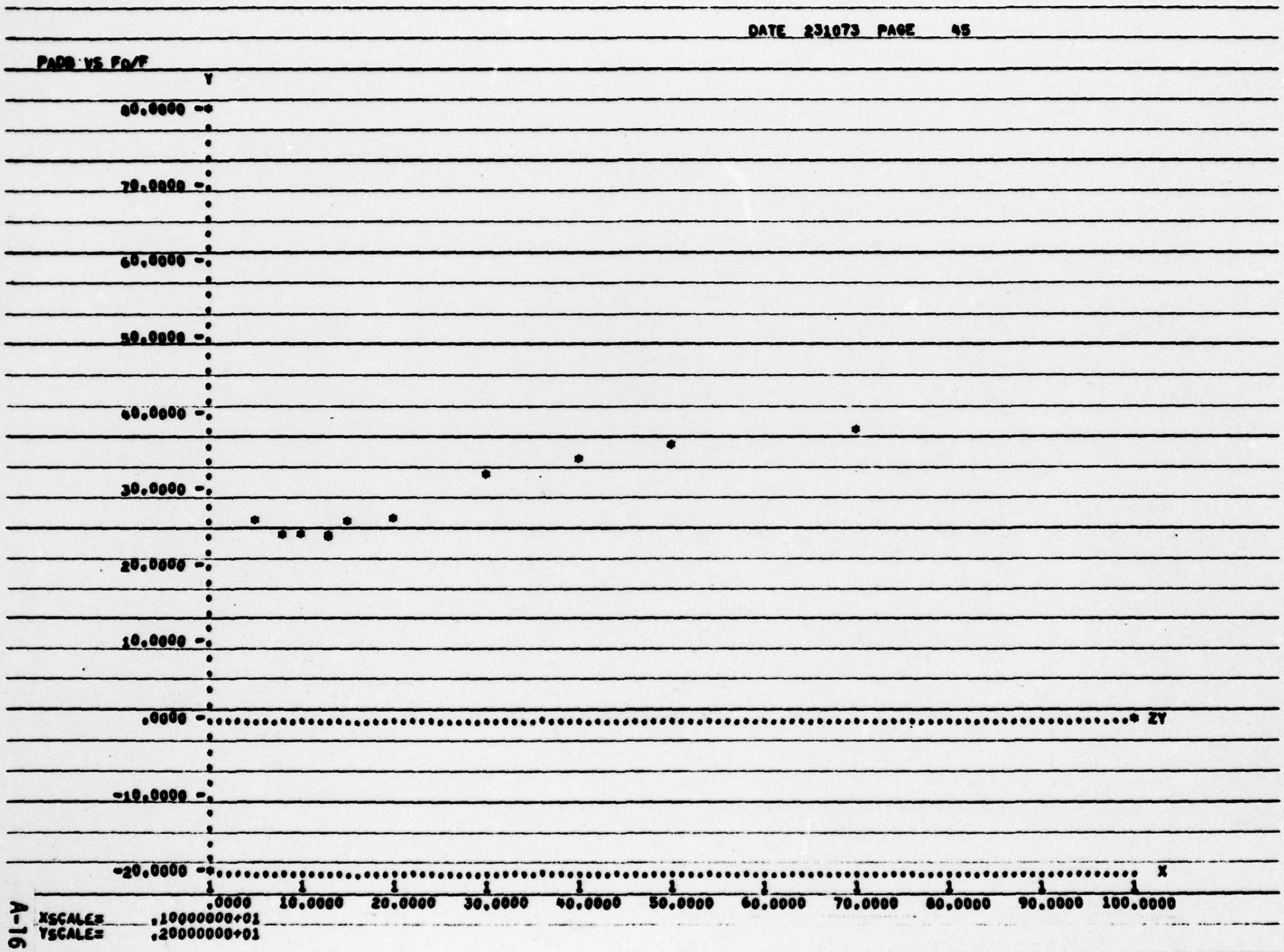
S= 35.

C= 1479.

A= .7854

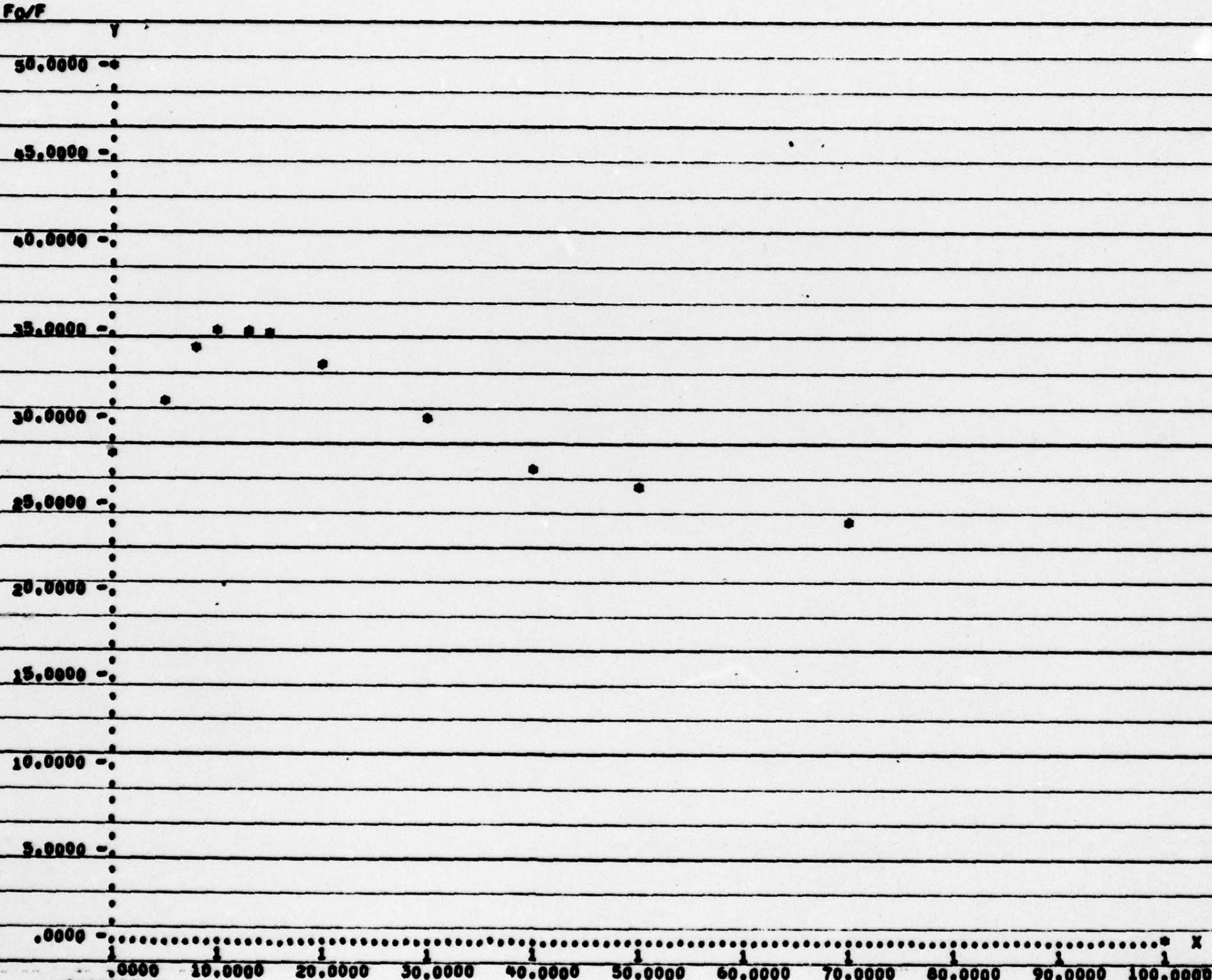
F= 3.000

BWP	BWS	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NOIS	ΔNOI
5.8	5.3	26.4	5.00	15.000	.000241	2079.	8.	260.9	30.1	90.2	127.2	150.8	-37.0	433.9	31.0	.9
3.9	3.9	24.7	7.50	22.500	.000506	968.	12.	82.7	33.6	89.9	129.1	156.1	-39.2	295.9	33.5	-.1
2.9	3.4	24.3	10.00	30.000	.000846	591.	16.	37.1	36.1	89.9	131.2	160.7	-41.2	267.2	34.7	-1.4
2.3	3.3	24.5	12.50	37.500	.001237	404.	20.	20.3	38.0	90.1	133.4	164.8	-43.3	283.8	35.1	-3.0
1.9	3.4	25.1	15.00	45.000	.001657	302.	24.	12.6	39.6	90.0	135.5	168.6	-45.5	322.8	34.8	-4.8
1.5	3.9	26.7	20.00	60.000	.002510	199.	32.	6.3	42.1	89.5	139.6	175.2	-50.1	469.3	33.5	-8.6
1.0	6.0	31.3	30.00	90.000	.004021	124.	48.	2.6	45.6	90.1	147.7	186.8	-57.6	1336.8	29.8	-15.8
.7	7.8	33.7	40.00	120.000	.005186	96.	64.	1.5	48.1	89.8	152.6	194.2	-62.8	2351.9	27.5	-20.6
.6	9.6	36.0	50.00	150.000	.006109	82.	80.	1.0	50.1	90.5	156.9	200.4	-66.4	4024.2	25.7	-24.4
.4	12.1	38.1	70.00	210.000	.007653	65.	112.	.6	53.0	90.0	161.9	208.3	-71.9	6406.8	23.7	-29.3
.0	.0	.0	100.00	300.000	.009969	50.	159.	.3	56.1	81.5	.0	210.4	-78.8		L*>210.	


DATE 231073 PAGE 45
PADB VS Fo/F
Y
80.0000
70.0000
60.0000
50.0000
40.0000
30.0000
20.0000
10.0000
.0000
-10.0000
-20.0000
ZY
X
.0000
10.0000
20.0000
30.0000
40.0000
50.0000
60.0000
70.0000
80.0000
90.0000
100.0000
XSCALE= .10000000+01
YSCALE= .20000000+01

DATE 231073 PAGE 46

NOIS VS Fo/F



XSCALE= .10000000+01
YSCALE= .10000000+01

DATE 231073 PAGE 46

T= 7.

D= .0

S= 35.

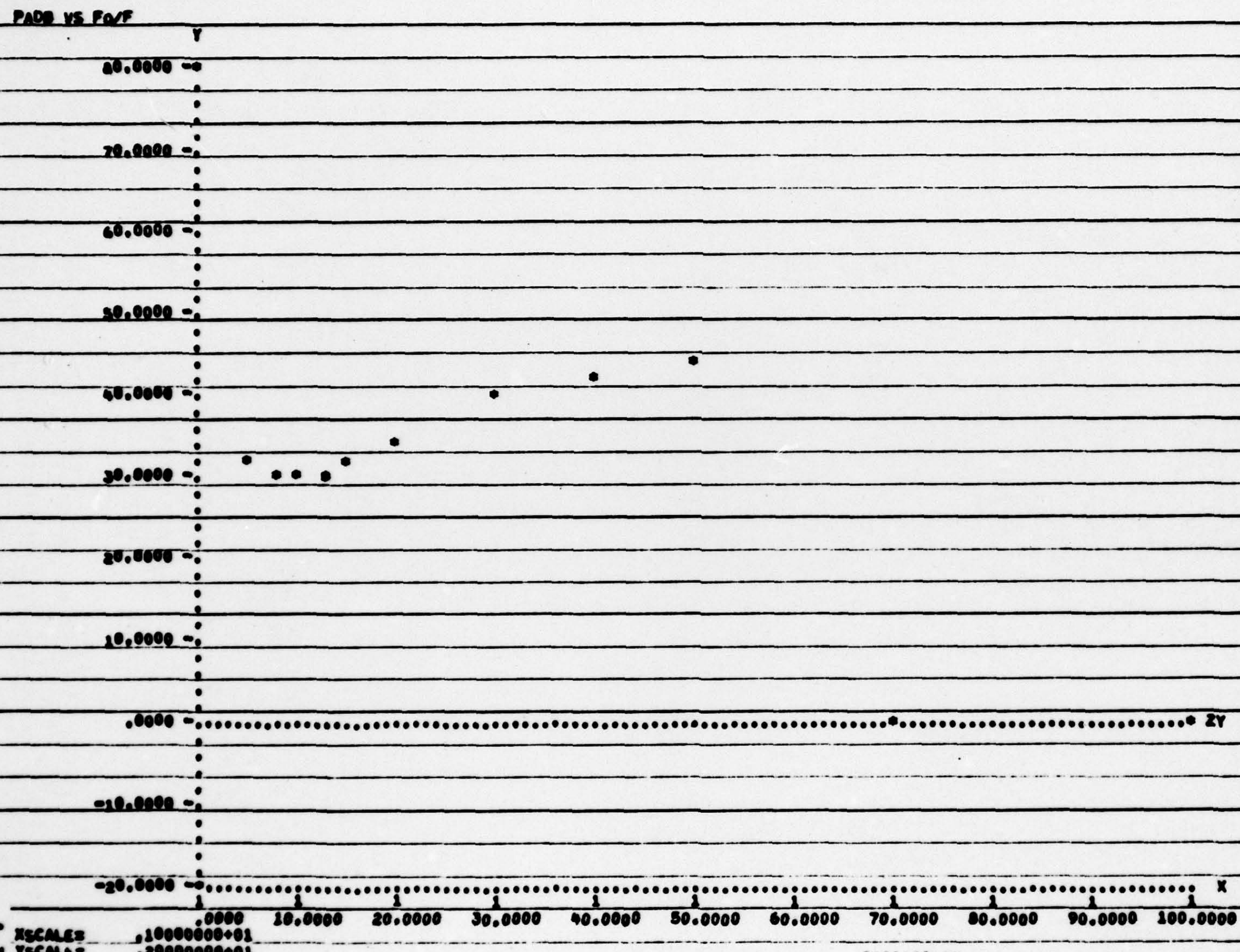
C= 1479.

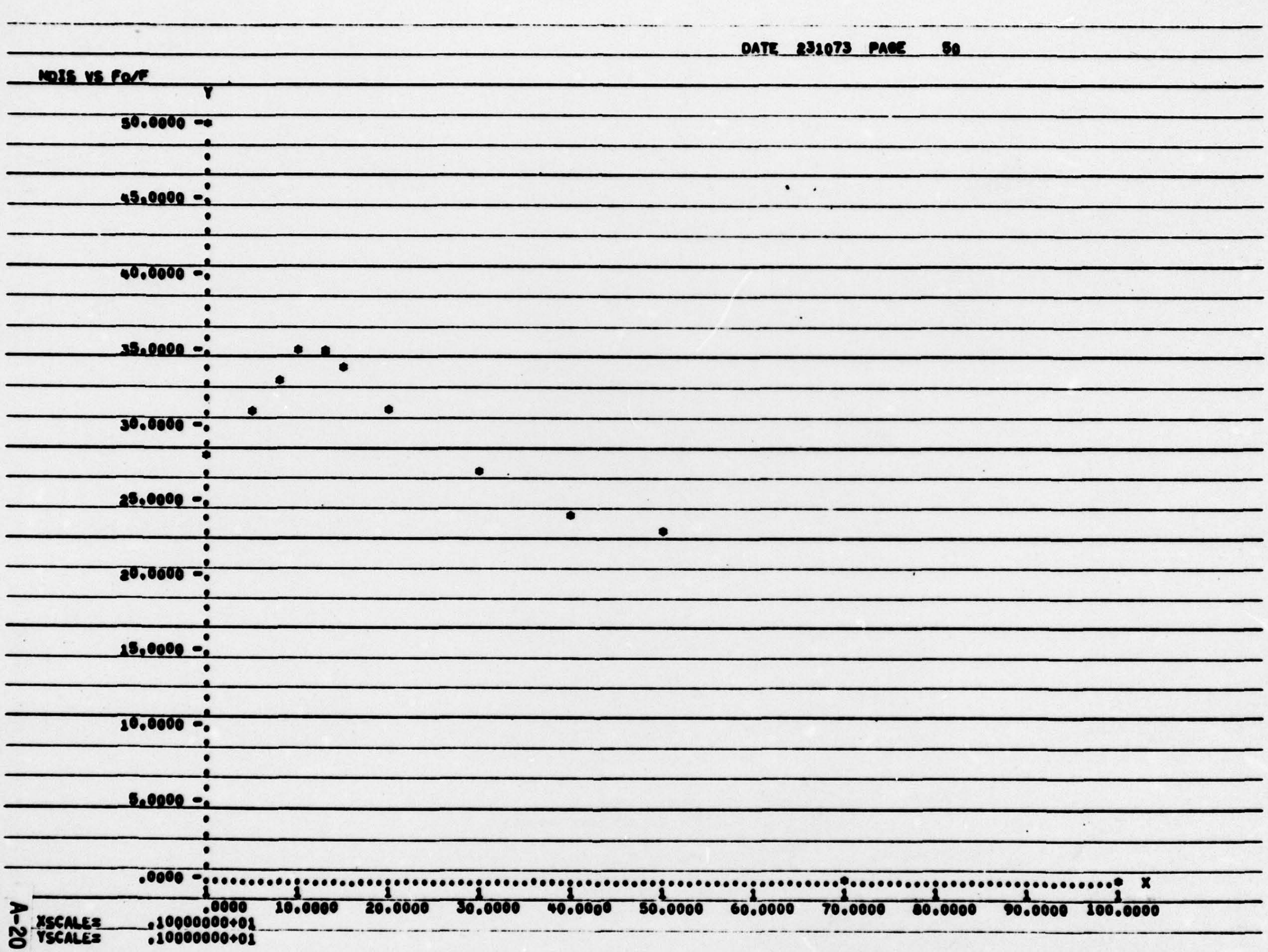
A= .7854

F= 3.000

BWP	BWS	PADB	FO/F	FO	AL	1/2AL	RO	1/2ALRO	NDIP	LSS	LSP	L*	θ	PA(WATTS)	NDIS	ΔNDI
5.8	5.3	31.3	5.00	15.000	.000241	2079.	8.	260.9	30.1	100.0	132.2	155.7	-32.2	1362.0	31.0	.9
3.9	3.9	29.7	7.50	22.500	.000506	988.	12.	82.7	33.6	99.6	134.1	161.1	-34.5	928.8	33.5	-.1
2.9	3.5	29.6	10.00	30.000	.000846	591.	16.	37.1	36.1	100.1	136.5	166.1	-36.4	922.3	34.5	-1.5
2.3	3.4	30.3	12.50	37.500	.001237	404.	20.	20.3	38.0	100.4	139.2	170.6	-38.7	1077.9	34.6	-3.4
1.9	3.7	31.3	15.00	45.000	.001657	302.	24.	12.6	39.6	100.2	141.7	174.8	-41.6	1348.3	34.0	-5.6
1.5	5.1	35.0	20.00	60.000	.002510	199.	32.	6.3	42.1	100.4	147.9	183.5	-47.5	3157.2	31.2	-10.9
1.0	8.7	40.0	30.00	90.000	.004021	124.	48.	2.6	45.6	100.1	156.4	195.5	-56.3	9893.4	26.6	-19.1
.7	11.6	42.8	40.00	120.000	.005186	96.	64.	1.5	48.1	100.3	161.7	203.3	-61.5	19145.7	24.1	-24.0
.6	13.6	44.3	50.00	150.000	.006109	82.	80.	1.0	50.1	99.9	165.2	208.7	-65.2	27073.7	22.7	-27.4
.0	.0	.0	70.00	210.000	.007653	65.	112.	.6	53.0	91.9	.0	210.4	-71.6		L*>210.	
.0	.0	.0	100.00	300.000	.009969	50.	159.	.3	56.1	81.5	.0	210.4	-78.8		L*>210.	

DATE 231073 PAGE 49




DATE 231073 PAGE 50
NDIS VS Fo/F
Y
50.0000
45.0000
40.0000
35.0000
30.0000
25.0000
20.0000
15.0000
10.0000
5.0000
.0000
X
.0000
10.0000
20.0000
30.0000
40.0000
50.0000
60.0000
70.0000
80.0000
90.0000
100.0000
XSCALE= .10000000+01
YSCALE= .10000000+01